DEA MODELS AND METHODS FOR EFFICIENCY IMPROVEMENT UNDER CONSTANT SUM OF INPUTS/OUTPUTS

Thesis Abstract

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Data Envelopment Analysis (DEA) is a technique to calculate the relative efficiency of firms/organizations or Decision Making Units (DMUs) operating in a similar environment, using multiple inputs to produce multiple outputs. It is a non-parametric mathematical programming technique that operates under certain assumptions that may or may not hold true in real life. One common assumption in DEA is that a DMU's inputs may be decreased (or outputs increased) without affecting the efficiency of other DMUs. However, this does not hold true if the total amount of input or output in a system is fixed. This is the constant sum constraint. The objective of this thesis is to develop models and methods to improve a DMU's efficiency while some of its inputs/outputs are under the constant sum constraint, without reducing the efficiency of the other DMUs.

There is no single model for solving this problem. To achieve the objective, we first need to determine the limits to which input/output values may be transferred from one DMU to another without reducing their efficiencies, then we need to determine which DMUs to target so that our observed DMU can achieve efficiency with the minimum change in input/output values. This entire process is achieved through methods and algorithms utilizing the DEA models that have been developed in this thesis. The thesis is divided into seven chapters followed by the bibliography.

The first chapter is the thesis introduction. It contains a brief history of Data Envelopment Analysis, and discusses various basic DEA models such as the Charnes-Cooper-Rhodes models, the Banker-Charnes-Cooper models, and the Slack-based models. It also contains a literature survey of existing papers on Constant Sum of Inputs (CSOI)/Constant Sum of Outputs (CSOO), and discusses the objectives and contributions of the thesis.

In the second chapter, models and methods have been developed to improve efficiency of a DMU under CSOI by reducing input, without reducing the efficiency of other DMUs, with no restrictions on input/output values and weights.

In the third chapter, models and methods have been developed in order to improve efficiency of a DMU under CSOI without reducing efficiency of other DMUs, while in the presence of weight restrictions under the Assurance Region method. While this chapter develops models to work under Assurance Region constraints, the models are easily

adaptable to any other weight and/or parameter constraints that the decision maker may choose to apply.

The fourth chapter introduces the CSOO constraint. The models developed for CSOI in previous chapters will be adapted for CSOO scenarios. Then, the models from this chapter and previous chapters will be combined so that a DMU under both CSOO and CSOI can improve its efficiency by changing both inputs and outputs at the same time. In this chapter, the concept of cross-efficiency is used as a way of selecting targets for the efficiency improvement strategy.

Chapter 5 addresses a special case of weight restrictions, when all DMUs are under a common set of weights. New models are developed to allow a DMU under common set of weights to improve efficiency under CSOO/CSOI without reducing the overall efficiency of other DMUs. Practical uses of common set of weights include situations where the DMUs are in sufficiently similar situations that they are expected to have similar weights on inputs/outputs, and for differentiating between DMUs with similar efficiency scores.

Chapter 6 discusses the problem when the DMUs are all part of larger networks. This chapter introduces new models and methods to allow a sub-DMU to improve its efficiency, while under CSOO/CSOI, or under Constant Sum of Intermediate Product, without reducing the efficiency of any of the networked DMUs.

Chapter 7 is the Conclusion. In it, we summarize the theoretical results and research contributions from the first six chapters. This chapter also contains a discussion on the managerial implications of our research, and discusses the limitations of our work and directions for future research.